Cloud Inhomogeneity from MODIS

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(Manuscript received 27 September 2004, in final form 16 June 2005)

ABSTRACT

Two full months (July 2003 and January 2004) of Moderate Resolution Imaging Spectroradiometer (MODIS) Atmosphere Level-3 data from the *Terra* and *Aqua* satellites are analyzed in order to characterize the horizontal variability of vertically integrated cloud optical thickness ("cloud inhomogeneity") at global scales. The monthly climatology of cloud inhomogeneity is expressed in terms of standard parameters, initially calculated for each day of the month at spatial scales of $1° \times 1°$ and subsequently averaged at monthly, zonal, and global scales. Geographical, diurnal, and seasonal changes of inhomogeneity parameters are examined separately for liquid and ice phases and separately over land and ocean. It is found that cloud inhomogeneity is overall weaker in summer than in winter. For liquid clouds, it is also consistently weaker for local morning than local afternoon and over land than ocean. Cloud inhomogeneity is comparable for liquid and ice clouds on a global scale, but with stronger spatial and temporal variations for the ice phase, and exhibits an average tendency to be weaker for near-overcast or overcast grid points of both phases. Depending on cloud phase, hemisphere, surface type, season, and time of day, hemispheric means of the inhomogeneity parameter ν (roughly the square of the ratio of optical thickness mean to standard deviation) have a wide range of ~1.7 to 4, while for the inhomogeneity parameter χ (the ratio of the logarithmic to linear mean) the range is from ~0.65 to 0.8. The results demonstrate that the MODIS Level-3 dataset is suitable for studying various aspects of cloud inhomogeneity and may prove invaluable for validating future cloud schemes in large-scale models capable of predicting subgrid variability.

1. Introduction

The nonlinear interplay of solar and longwave radiation with cloud optical properties is a fundamental aspect of atmospheric radiative transfer with implications for the earth's climate that were already noted many years ago (e.g., Harshvardhan and Randall 1985). In recent years, a plethora of studies examined various aspects of this interplay but, to our knowledge, only a handful was of global scope, namely the observational study of Rossow et al. (2002, hereafter RDC) and the model-based studies of Oreopoulos et al. (2004) and Räisänen et al. (2004). The present study, focusing only on a specific aspect of cloud variability, namely the horizontal fluctuations of total optical thickness τ (hereafter "cloud inhomogeneity"), is also of global scope. Studies on this topic preceding RDC provided an incomplete and often conflicting picture of the magnitude of cloud inhomogeneity, as they were based on a limited number of scenes and different observational methods (Cahalan et al. 1994, 1995; Barker 1996; Oreopoulos and Davies 1998a; Pincus et al. 1999). In the following we make the case that, similar to the International Satellite Cloud Climatology Project (ISCCP) products used by RDC, higher-level cloud products from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard the *Terra* and *Aqua* satellites can provide a detailed picture of cloud inhomogeneity.

Knowledge of the actual geographical and seasonal distribution of cloud inhomogeneity is essential in our effort to make it a diagnosed or predicted quantity that will improve representation of physical processes involving clouds in large-scale models (LSMs). These in-

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